BRH/DEP 70-27

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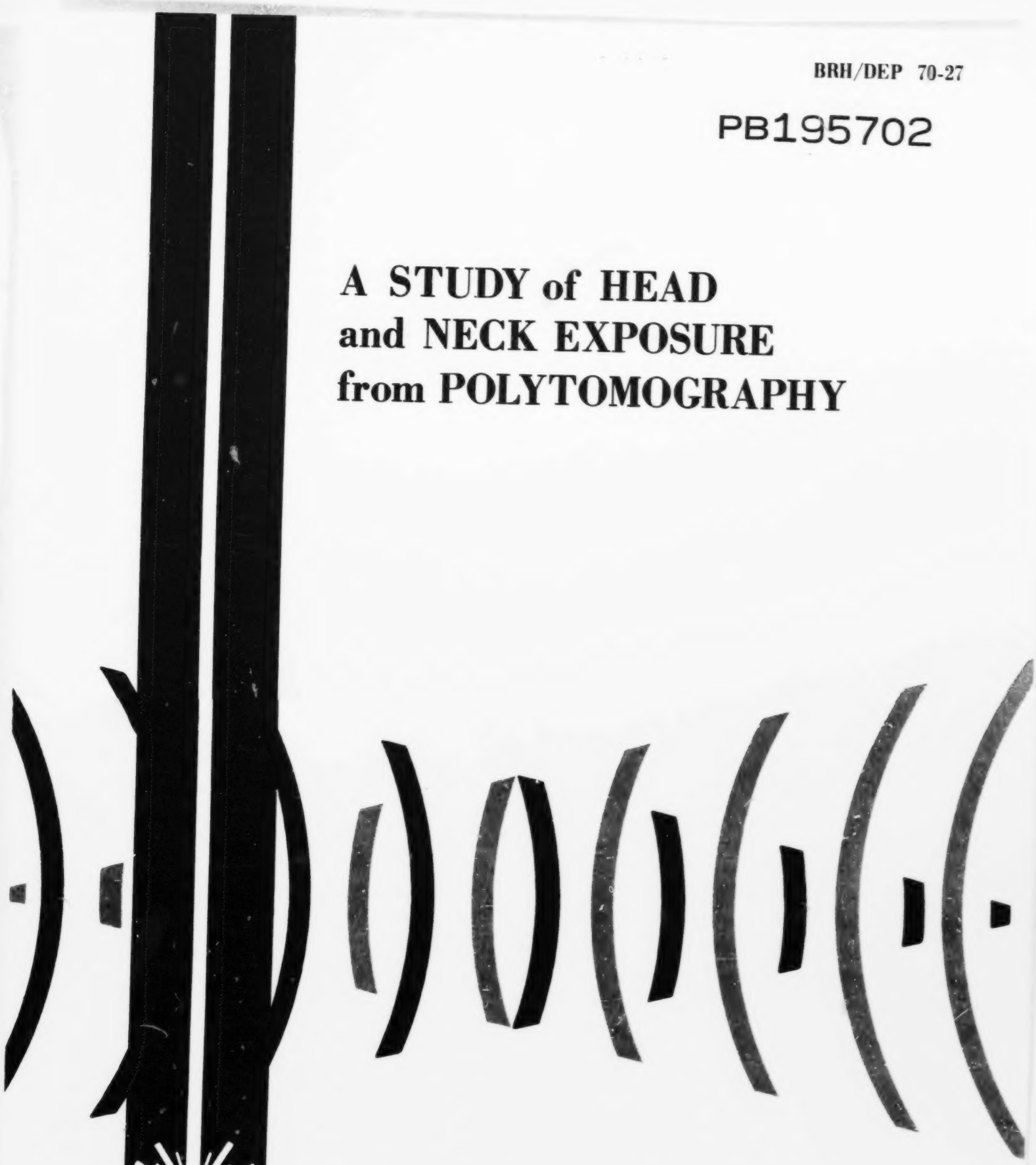
A STUDY of HEAD and NECK EXPOSURE from POLYTOMOGRAPHY



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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(continued on inside of back cover)

BRH/DEP 70-27

A STUDY of HEAD and NECK EXPOSURE from POLYTOMOGRAPHY

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National Institutes of Health

November 1970

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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Rockville, Maryland 20852

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FOREWORD

The Bureau of Radiological Health continues to carry out a national program designed to reduce the exposure of man to hazardous ionizing and nonionizing radiation.

Within the Bureau, the Division of Electronic Products (1) develops and administers performance standards for radiation emissions from electronic products, (2) studies and evaluates emissions of and conditions of exposure to electronic product radiation and intense magnetic fields, (3) conducts or supports research, training, development, and inspections to control and minimize such hazards, and (4) tests and evaluates the effectiveness of procedures and techniques for minimizing such exposures.

The Bureau publishes its findings in Radiological Health Data and Reports (a monthly publication), Public Health Service numbered reports, appropriate scientific journals, and technical report series for the Bureau's divisions, offices, and laboratories.

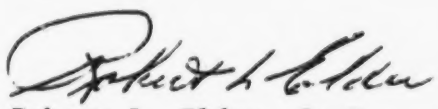
The technical reports of the Division of Electronic Products (DEP) allow comprehensive and rapid publishing of the results of intramural and contractor projects. The reports are distributed to State and local radiological health program personnel, Bureau technical staff, Bureau advisory committee members, university radiation safety officers, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested individuals. These reports are also included in the collections of the Library of Congress and the National Technical Information Service.

I encourage the readers of these reports to inform the Bureau of any omissions or errors. Your additional comments or requests for further information are also solicited.

John C. Villforth
Director
Bureau of Radiological Health

PREFACE

The Division of Electronic Products, Bureau of Radiological Health, as a part of its responsibility under the "Radiation Control for Health and Safety Act of 1968", conducts a program to study and evaluate emission of and conditions of exposure to electronic product radiation. This report describes an investigation of radiation exposures to the head and neck regions of patients undergoing poly-tomographic studies of the sella turcica, paranasal sinuses and petrous pyramid. Dosimetry results from 27 clinical procedures are presented.



Robert L. Elder, Sc.D.
Director
Division of Electronic Products

CONTENTS

	Page
FOREWORD	iii
PREFACE	v
ABSTRACT	ix
ACKNOWLEDGEMENTS	x
INTRODUCTION	1
PROCEDURE	1
RESULTS	3
SELLA TURCICA	3
PARANASAL SINUSES	3
PETROUS PYRAMID	3
DISCUSSION	4

ABSTRACT

An investigation was conducted to determine radiation exposures to the head and neck regions of patients undergoing polytomographic studies of the sella turcica, paranasal sinuses, and petrous pyramid. The highest exposures were measured at the eyelid region for studies of the sella turcica and paranasal sinuses. In studies of the petrous pyramid, the highest exposures were recorded in the external auditory canals. Variation in the total number of exposures, the ratio of frontal and lateral exposures, and beam collimation are cited as principal causes of the wide range of values recorded for a given dosimeter location and type of examination. To reduce eye exposures, it is recommended that PA rather than AP projections be used for tomography of the petrous pyramid, sella turcica, sphenoid sinus, and other mid- and posteriorly-located structures of the skull.

ACKNOWLEDGMENTS

The authors wish to express their gratitude to the radiologic technicians at the Clinical Center of the National Institutes of Health for their assistance and especially to Mr. Pomeroy Skeeter of the X-ray Exposure Control Laboratory without whose help this study would not have been possible.

A STUDY OF HEAD AND NECK EXPOSURE FROM POLYTOMOGRAPHY

INTRODUCTION

The hypocycloidal motion of the x-ray tube used in polytomography has made possible a definite improvement in the radiographic assessment of bony structures of the skull and facial bones. The increasing clinical use of polytomography in the past several years has aroused curiosity regarding patient exposure from the multiple thin-section radiographs made with this apparatus. A review of the literature revealed only three reports on this subject.[1-3]

Therefore, an investigation was started to determine exposures received by patients undergoing radiographic studies of the paranasal sinuses, sella turcica, and petrous pyramid. The radiography was performed on the Polytome[4] unit at the Clinical Center of the National Institutes of Health. The hypocycloidal movement of this apparatus was used for all studies.

PROCEDURE

Dosimetric measurements were made, where clinically feasible, by placing approximately 160 milligrams per capsule of thermoluminescent dosimetry powder (TLD-100)[5] in number 5 gelatin capsules or in sealed Tygon tubing at the following positions: right and left upper closed mid-eyelids, right and left buccal mucosal area, right and left external auditory canal, and right and left anterior neck at the level of the thyroid cartilage (fig.1). These dosimeters were left in place during the entire examination of each patient.

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[1]STIEVE, F. E., Radiation exposure to body section radiography. Acta Radiologica 55:465-485 (1961).

[2]MUNDNICH, K., and K. W. FREY, The tomogram of the ear. Stuttgart, Thieme (1959).

[3]REISNER, K., Tomography in inner and middle ear malformations. Radiology 92:11-20 (January 1969).

[4]Trademark of North American Philips Corporation, New York.

[5]Harshaw Chemical Company, Cleveland, Ohio.

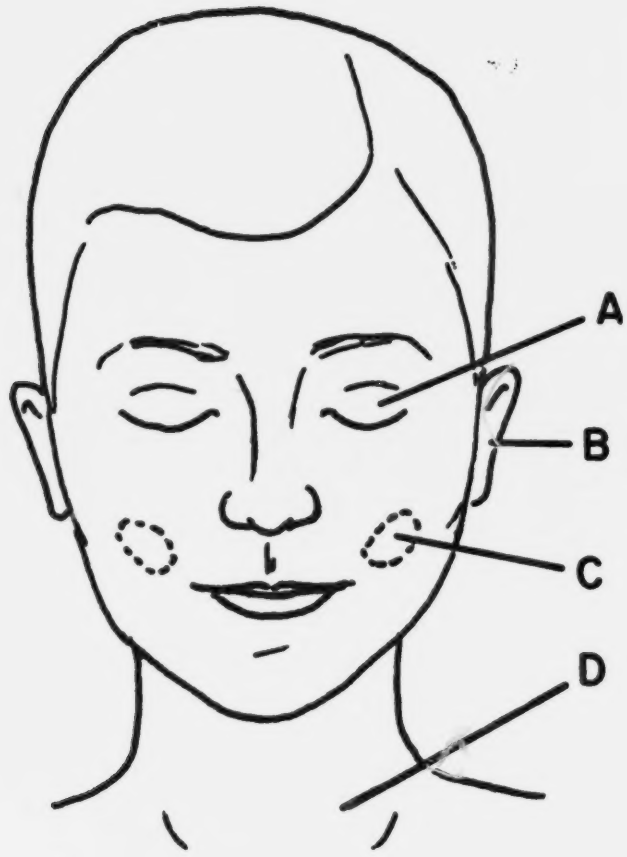
A
B
C
D
Capital letters indicate approximate placement of LiF dosimeters over one-half of the face of a simulated patient.

Figure 1. Dosimeter positions during clinical study.

The TLD powder was annealed at 400°C for one hour, cooled to room temperature, and annealed at 100°C for one hour between each use. After each annealing, the TLD powder was calibrated for 60 kVp, 1.8 mm Al HVL x rays. Two unexposed dosimeters from each clinical study were used as controls. The dosimeters were read by means of a TLD reader that reaches a sample temperature of 300°C during a 17-second readout. The TLD measurements had a standard error of ± 3 percent.

RESULTS

A total of 27 procedures performed on 26 patients have been analyzed. Twelve females and 14 males were studied. Ages ranged from 9 years to 68 years. Studies have been divided into three principal groups according to the anatomical area of interest.

SELLA TURCICA

Studies of the sella turcica were most frequent and were performed on 14 patients (table 1). The number of exposures per patient ranged from 17 to 54 with a mean of 25. Approximately one-half of the exposures were taken in the anterior-posterior (AP) projection and one-half in the lateral projection (predominantly right lateral). Peak kilovoltage ranged from 60 to 75 for the frontal examinations and from 50 to 65 for the lateral studies. The average field size was 12 by 13 cm. The highest exposures were generally measured at the eyelid region with values ranging from 0.3 to 22 roentgens per study at this site (table 1).

PARANASAL SINUSES

Studies of the paranasal sinuses and facial bones delivered the highest exposures to the orbital regions (table 2). Five such studies were performed with an average of 32 exposures per examination. The field size used was the same as with the sella turcica studies. The orbital regions received the largest total exposures per examination, ranging from 4 to 40 roentgens.

PETROUS PYRAMID

The largest mean number of exposures per study, 47, was taken with studies of the petrous pyramid (table 3). The field size was smaller than with either of the other groups, averaging 9.2 by 6 cm. The highest exposures for study of the petrous pyramid were recorded by dosimeters placed in the external auditory canals, where readings ranged from 0.1 to 30 roentgens.

DISCUSSION

A review of tables 1-3 reveals the considerable variation in patient exposure which is possible for a particular study using hypocycloidal tomography. A number of variables makes such a wide range of measured exposures virtually inevitable. Prominent among these are the total number of exposures taken, the ratio of frontal to lateral exposures, the mAs and kVp used, the field size and anatomic areas exposed, and placement of dosimeters as well as factors such as patient variability. From one examination to another, dosimeter placement was believed to be accurate and probably within 0.5 cm. It is obvious that this variation at the edge of a well-collimated radiation beam could cause considerable differences in measurements. Therefore, in view of the relatively constant mAs and kVp values used for a given study type, the number of exposures, frontal/lateral ratio, and collimation would appear to be the principal causes of variation.

It is now widely recognized that medical x-ray exposures constitute the largest source of population exposure to man-made x radiation. It is apparent that a complete study using the Polytome constitutes a relatively large, well-localized single patient exposure, perhaps only equalled in modern diagnostic radiology by other methods of tomography and special angiographic studies. For a series of 25 exposures, Mundnich and Frey[6] found a skin dose at the level of the gonads to be 0.5 to 3 mrad, and Reisner[7] measured 2.4 mrads. Measurement of the gonadal dose using the Alderson-Machlett Rando Phantom during a simulated phantom study (48 exposures) of the temporal bone resulted in a dose of less than 5 mrad. From these studies it can readily be seen that the performance of head and neck tomography results in a gonadal dose which is quite low.

Since the completion of this study, Chin, Anderson, and Gilbertson[8] have noted that the use of lead eye shields may, in certain situations, permit lower exposures to the lens without obscuring diagnostic detail. The authors, however, have had no personal experience with this technique.

Although it seems unlikely, with current equipment and techniques, that total patient exposure can be significantly reduced, the use of a PA rather than an AP projection for studies of the petrous pyramid, sella turcica, sphenoid sinus, and other mid- or posteriorly-located structures of the skull should significantly reduce the dose to the eye. Consideration of possible deleterious radiation effects should make this a desirable modification, although patient positioning will be slightly more difficult.

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[6]See footnote 2 on page 1.

[7]See footnote 3 on page 1.

[8]CHIN, F. K., M.D., W. B. ANDERSON, M.D., and J. D. GILBERTSON, M.D., Radiation dose to critical organs during petrous tomography. Radiology 94:623-627 (March 1970).

Table 1. Sella turcica

Patient	Projection	kVp	mAs	No. of exposures		Exposure (roentgens)							
				AP/LAT	Total	R Eye	L Eye	R Thyroid	L Thyroid	R Ear	L Ear	R Mouth	L Mouth
H.P.	AP LAT	73 67	240 240	10 12	22	7.4	7.4	0.03	0.04	0.26	7.0	0.22	0.12
G.S.	AP LAT	70-75 60	240 240	15 12	27	13.0	9.6	0.03	0.04	0.22	6.7	0.49	0.46
D.G.	AP LAT	65-74 60	240 240	30 24	54	21.0	22.0	1.4	2.3	1.3	20.0	10.00	9.2
G.H.	AP LAT	63 55	240 240	6 12	18	4.7	4.5	0.01	0.02	0.15	6.6	0.21	0.14
M.P.	AP LAT	67 57	240 240	9 13	22	6.3	7.3	0.05	0.05	0.15	5.9	0.12	0.16
C.P.	AP LAT	63-66 57	240 240	12 12	24	12.0	10.0	0.03	0.03	Lost	Lost	0.41	0.53
A.L.	AP LAT	60-63 50-53	180 240	15 10	25	10.0	0.3	0.03	0.04	0.22	3.0	0.29	0.22
B.C.	AP LAT	65 55	240 240	10 9	19	5.9	7.6	0.02	0.02	0.17	4.3	0.19	0.34
E.H.	AP LAT	63-68 55	240 240	18 12	30	16.0	19.0	0.11	0.11	0.67	5.2	0.84	0.84
M.M.	AP LAT	60 50	180 180	9 9	18	8.8	10.0	0.03	0.04	0.42	0.65	0.66	0.32
M.B.	AP LAT	65-70 56-60	240 240	9 15	24	9.9	9.6	0.05	0.06	0.31	16.0	0.26	0.52
H.W.	AP LAT	64-75 60-65	240 240	18 12	30	13.0	19.0	0.04	0.04	8.9	0.27	0.10	0.11
H.C.	AP LAT	65-72 55	240 240	12 10	22	11.0	14.0	0.03	0.03	0.30	2.9	0.13	0.23
M.G.	AP LAT	64 54	240 240	6 11	17	Lost	7.4	0.04	0.04	0.19	5.4	0.24	0.40

Table 2. Paranasal sinuses and facial bones

Patient	Projection	kVp	mAs	No. of exposures		Exposure (roentgens)							
				AP/LAT	Total	R Eye	L Eye	R Thyroid	L Thyroid	R Ear	L Ear	R Mouth	L Mouth
B.F.	AP LAT	50-55 54	240 240	8 12	20	13	4.2	0.4	0.03				
J.S.	AP LAT	58 50	240 180	24 20	44	12	23.0	0.27	0.47	0.27	5.3	8.4	14
E.R.	AP LAT	65 65	240 240	14 26	40	27	40.0	0.51	0.56	1.3	21.0	11.0	21
E.P. (Facial)	AP LAT	80 57	120 120	21 10	31	8.1	13.0	0.92	1.7	0.36	5.3	5.2	11
J.H. (Facial)	Cuts Tests	58 53	240 240	23+3 (All AP)	26	28.0	24.0	0.24	0.21	0.77	0.77	10.6	11

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Table 3. Petrous pyramid

Patient	Projection	kVp	mAs	No. of exposures		Exposure (roentgens)							
				AP/LAT	Total	R Eye	L Eye	R Thyroid	L Thyroid	R Ear	L Ear	R Mouth	L Mouth
M.H.	AP RPO LAT	75-78 78 68	240	12 26	38	17.0	13	0.07	0.07	0.66	18	--	--
T.K.	AP LAT	62 55	120	19 10	29	6.0	3.5	0.07	0.08	3.8	15	0.30	0.19
N.T.(2nd study)	AP LAT	65 55	240	15 18	33	12.0	0.44	0.01	0.02	17	0.09	0.22	0.05
A.C	AP LAT	61-68 53-57	240	18 26	44	6.7	0.46	0.03	0.02	30	0.15	0.22	0.06
O.E.	AP LAT	58 53	180	24 32	56	5.2	5.0	0.05	0.06	0.29	14	0.19	0.20
H.K.	AP LAT	63-65 63	240	31 43	74	12.0	24	0.04	0.04	1.1	0.53	0.53	2.7
L.B.	AP LAT	63 57	240	31 31	62	4.3	7.8	0.05	Lost	Lost	20	4.4	2.9
N.T.	AP LAT	60-65 55	240	15 18	33	0.47	6.40	0.02	0.02	0.07	1.2	0.04	0.11

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U.S. Department of Health, Education, and Welfare, Public Health Service Publication Number BRH/DEP 70- (November 1970), 7 pp. (limited distribution).

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List of Publications

(continued from inside of front cover)

	Title	
BRH/DEP 70-8	Development of Liquid Crystal Microwave Power Density Meter (May 1970)	PB 191 396
BRH/DEP 70-9	Product Testing and Evaluation of Giant View® TV Projector (May 1970)	PB 191 906
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BRH/DEP 70-24	In-Plant Survey of Television Receivers for X-radiation Emission Capability (September 1970)	PB 194 316
BRH/DEP 70-25	Laboratory Testing and Evaluation of Microwave Ovens (October 1970)	FB 194 484
BRH/DEP 70-26	Electronic Product Radiation and the Health Physicist - Health Physics Society Fourth Annual Midyear Topical Symposium (October 1970)	